VHF DF LOOP AERIAL

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An interesting exercise, not only in radio direction finding but in map reading as well, is provided by v.h.f. DF hunts, frequently run by radio clubs. When a *horizontally* polarised aerial is used by the hidden transmitter, then a small beam aerial or dipole could be used to obtain direction, although with a beam one has to estimate the maximum received signal, which is not defined enough for obtaining accurate bearings. Providing it is properly balanced, a dipole is better, as the nulls in the polar pattern (minimum signals) are much more defined. If the hidden transmitter is using a *vertically* polarised aerial, then a dipole is of no use, as it becomes omnidirectional when used vertically. A small conventional beam aerial presents the same problem, in that the maximum signal indication is not defined well enough to obtain accurate bearings. The 2-element ZL Special (*PW*, May '77) is an exception however, and is very useful for DF work as it has one fairly sharp null. Its polar pattern is cardioid when the aerial is operated vertically, but more of this later.

The loop aerial described in this article is for use when signals are from a *vertically* polarised source. It consists of a split loop, one half-wavelength in circumference, tuned and balanced to operate with 50 ohm coaxial cable as shown in Fig. 1(a). The current and voltage distribution, together with the direction of the current in each half-loop (arrows) are shown in Fig. 1(b). Since the currents in each half are in phase opposition, the polar pattern is a figure-of-eight, like that of a horizontal dipole, with two maxima and two minima as in Fig. 1(c).

This loop will also operate very efficiently as a transmitting aerial with a v.s.w.r. close to 1 : 1 when properly tuned. This means that stations, mobile or handheld, taking part in the DF hunt can communicate with each other to pass bearings and map readings, etc., without having to change aerials. It is appreciated that this loop system does not provide a means of sensing, i.e. of determining which minimum is giving true direction, but this is not greatly important when two or more stations at reasonable distances apart are working as a team. Information on direction finding is given later.

Making the Loop Aerial

General construction details for the loop are given in Fig. 2. The loop itself is made from 4·7mm ($\frac{3}{16}$ in) diameter aluminium rod although 6·3mm ($\frac{1}{4}$in) may be used. Bending the rod to form the two half-circles is not difficult if done gradually and with aid of gentle heating from a small blow-lamp. The bottom ends are flattened by hammering on a hard surface, after which they can be filed smooth and drilled 4BA clearance as shown.

The lower mounting block, and the top block that supports the upper ends and keeps them separated, must be made from Perspex or similar good-quality insulating material. The upper ends are at high r.f. potential. The box for mounting the loop on and housing the two 30pF trimmers may be a plastics electrical junction box, or similar, with removable lid and of dimensions approximately as shown. The handle can be a short length of 25mm dowel or broomstick, secured to the underside of the box with a wooden collar, by gluing and screwing.

The diagram Fig. 3 shows how provision is made for a compass platform and a sighting bar. Note also the hole each side of the box allowing access to the 30pF trimmers after the aerial is assembled and ready for tuning. Connection to the loop from a length of 50 ohm coaxial cable is made via the S0239 socket at the base of the box.

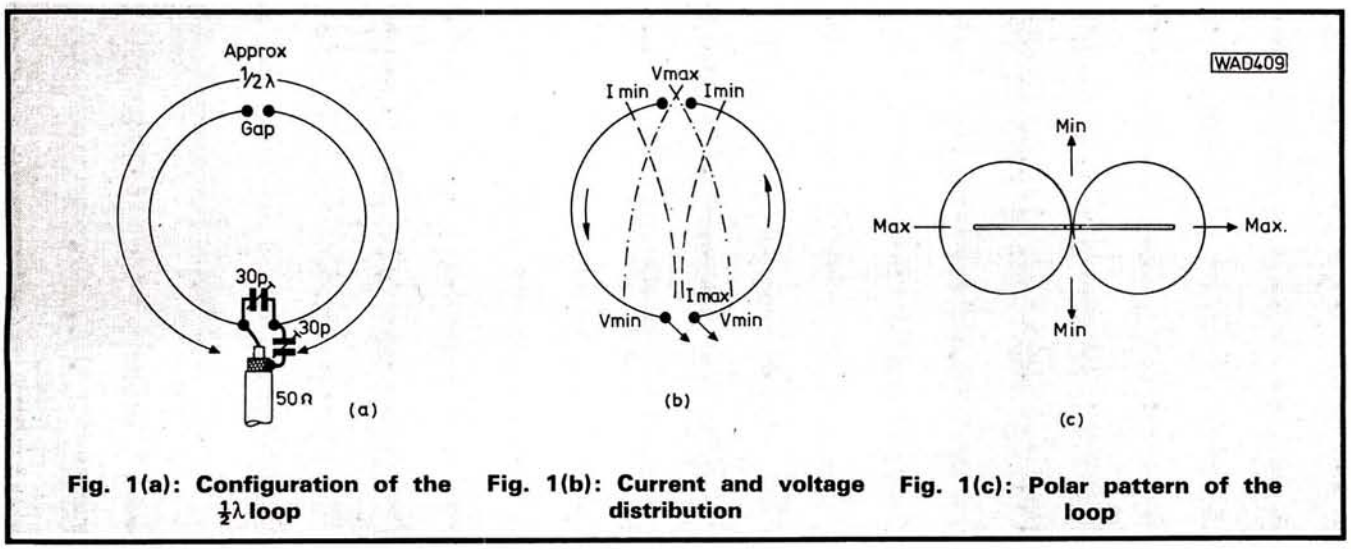

Fig. 1(a): Configuration of the $\frac{1}{2}\lambda$ loop

Fig. 1(b): Current and voltage distribution

Fig. 1(c): Polar pattern of the loop

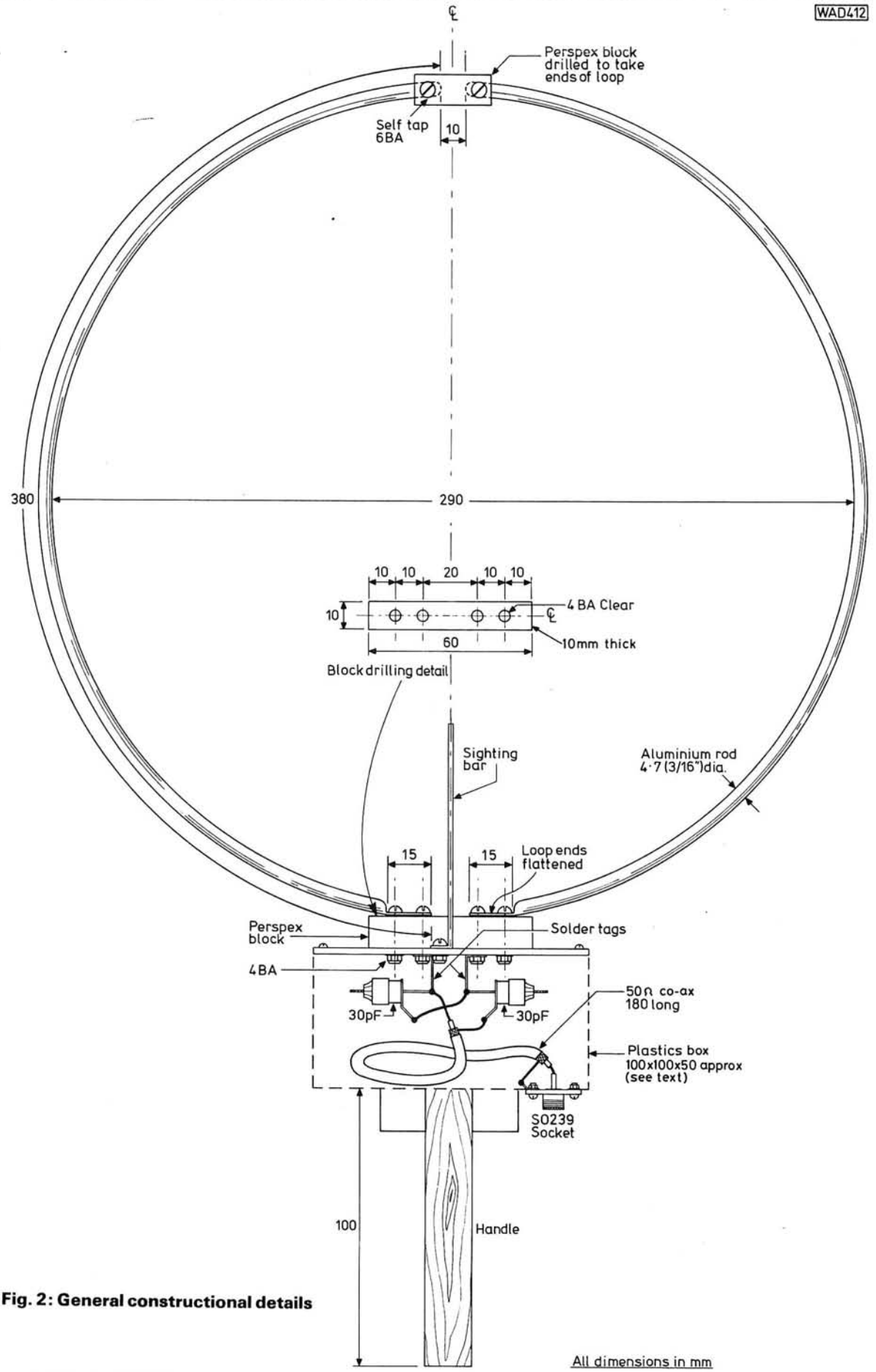

Fig. 2: General constructional details

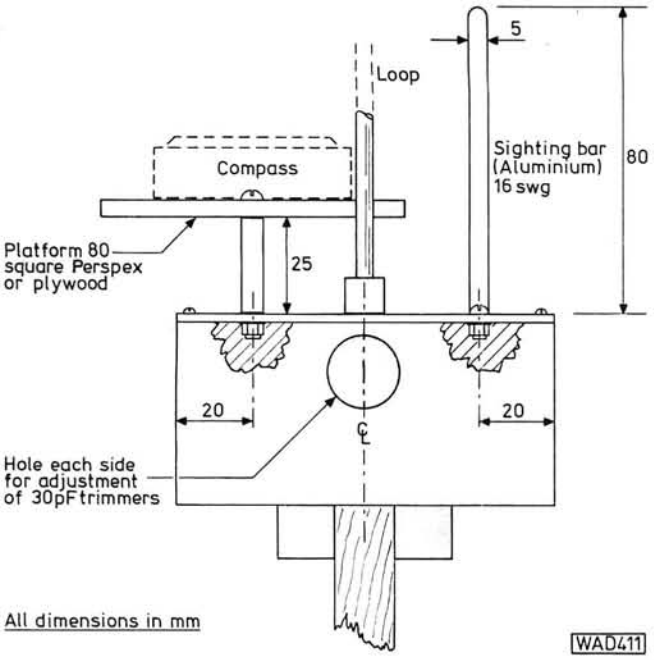

Fig. 3: Arrangement for a compass platform

Tuning and Checking the Loop

The length of the external coaxial cable will depend on how the loop will be used. For example, when connected to a mobile rig, one will need to use the loop a metre or more from the car to avoid reflection from the car body, so that about 3 metres of cable should be used. Handheld transceiver operators will need only about 1 metre. The length is otherwise not critical and may be chosen entirely to suit convenience.

With the loop aerial connected to the transmitter/receiver and with the length of coaxial cable decided upon, all that is necessary is to adjust the two trimmers for maximum power (on transmit) into the aerial, or better still, minimum v.s.w.r. Do this at midband (145MHz) and tuning will hold good to the outer limits of the band. If a receiver only is to be used, then adjust the trimmers until a received signal is at maximum. Remember the loop has two nulls and two maxima, so for a transmitting test with another station the loop must be end-on to that station for maximum signal. Checks for the two nulls (minimum signal) should be made out of doors and well clear of other 2m aerials, and indeed any other conducting elements likely to cause reflection and give rise to false nulls. Each null should be sharp and reduce a received signal down to noise level or even completely out. Check also that the nulls are 180° apart.

A small hand type compass can now be fitted to the compass platform. It need not be permanently fixed, but instead secured with strong elastic bands and aligned so that 0/360° points to one side of the loop, i.e. in the direction of the null in line with the sighting bar.

Direction Finding

The polar pattern shown in Fig. 4, taken with the writer's Polar Pattern Indicator aerial performance display, is from the prototype loop. It clearly shows a virtually perfect figure-of-eight shape with two well-defined nulls at 305° and 125° respectively and therefore 180° apart. The other pattern (Fig. 5) is an almost perfect cardioid from a two-element ZL Special. In team operation in a DF hunt this can be used for "sense" of direction. Once this has been obtained, the remainder of the team can be notified that the hidden transmitter is to the North or the East (or whatever) general direction from them.

For those new to radio direction finding the following notes may be found useful. Ordnance Survey maps 1 : 50 000 series with 1 kilometre squares are ideal for DF work. Indeed, they are essential if accurate results are to be obtained, especially when the start of operations may be several miles from the transmitter to be located. A team of three is ideal if location is to be found quickly, although two operators could work together fairly efficiently. A lone operator would need to move about a lot more in order to get the necessary cross bearings.

The illustration (Fig. 6) is based on the 1km squares of a 1 : 50 000 Ordnance Survey map, and here the hidden transmitter is on a reference of approx 67 Easting and 92 Northing (note that on a full-scale map, the Eastings and Northings are each given in three figures, making six

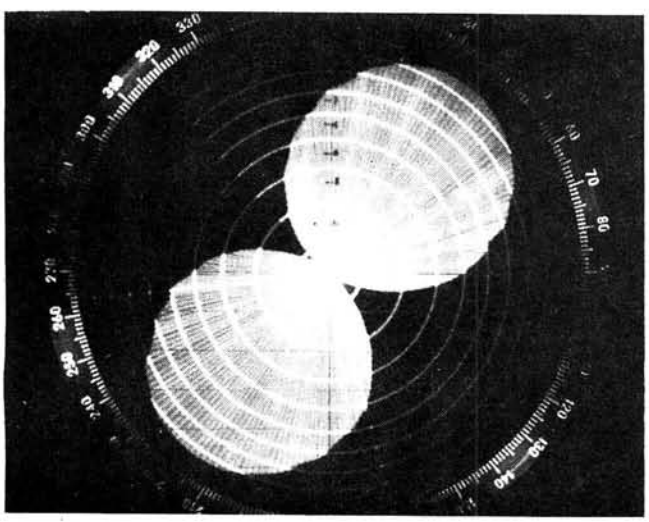

Fig. 4: Actual polar pattern of prototype loop aerial

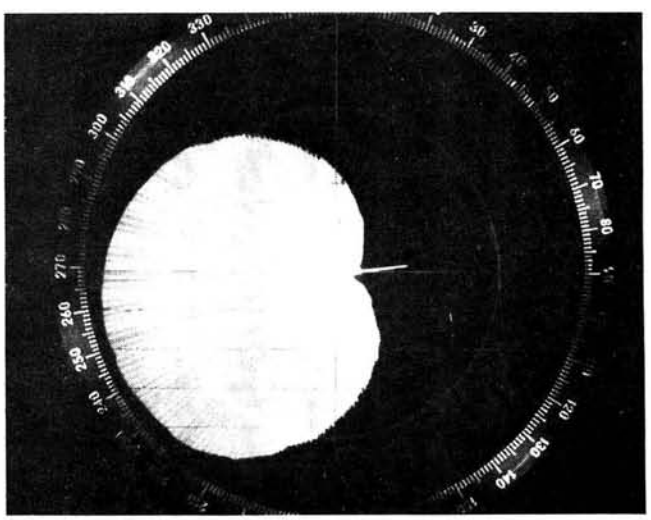

Fig. 5: Cardioid pattern of the 2-element ZL Special

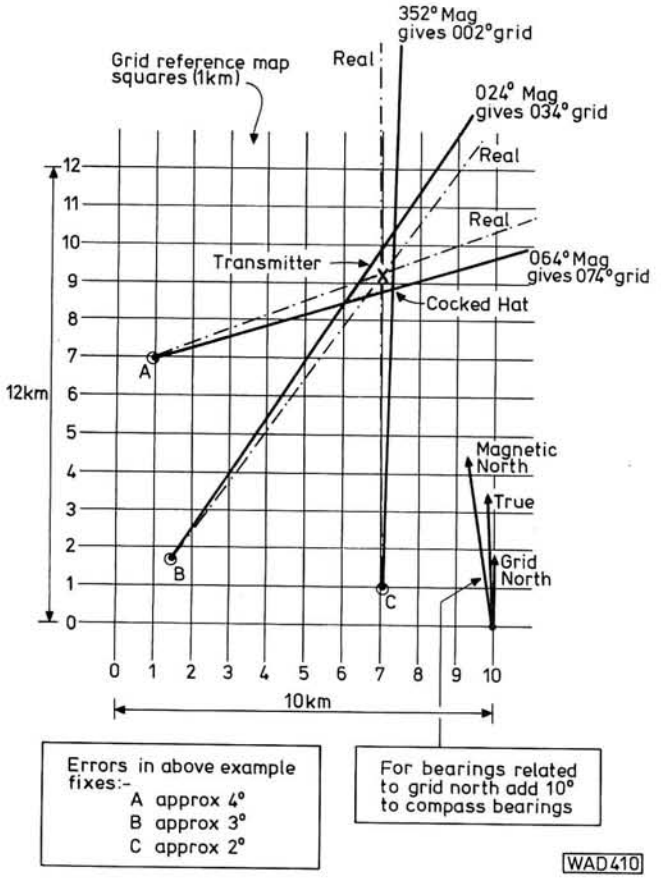

Fig. 6: Example of obtaining a fix on a hidden transmitter from three positions. Errors shown are about average in practice, but do produce the "cocked hat" area enclosing the true position

figures for the full grid reference). The bearings taken by DF stations A, B and C are shown by the solid lines and are about average as far as error is concerned. They form a triangle of "cocked hat", around the true position of the transmitter. Remember that we have started from several miles away, but at this stage have located the transmitter to within about a square kilometre. The next step is for each member of the team to move in closer, in this case A goes to point 96, B to 86 and C to 88. Even with similar errors in bearing, e.g., between 2 and 4 degrees, the now much shorter range should establish a location of the transmitter to within an area of about 0·1km or a little over 100 yards square. The procedure can be repeated and again, with average errors, location to within 0·01km or about 10 yards square should be possible.

Remember, that an Ordnance Survey map grid North is slightly different from true North, and magnetic (compass) North is different from true. The total amount to be added to a magnetic bearing for the grid map is about 10°. If, for example, your magnetic bearing is 024° then using the vertical grid lines of the map as 0/360° (North) the bearing to be plotted on the map will be 034°.

Ascertaining the null is usually best done by listening, preferably on headphones, and accuracy in obtaining the minimum stems largely from practice in aurally estimating this, although a signal level meter is helpful of course. Remember that nulls can sometimes be confused by the arrival of signals from other than the direct path, due to reflection, so if a null appears to be confused or not well defined, try moving to another position. ●

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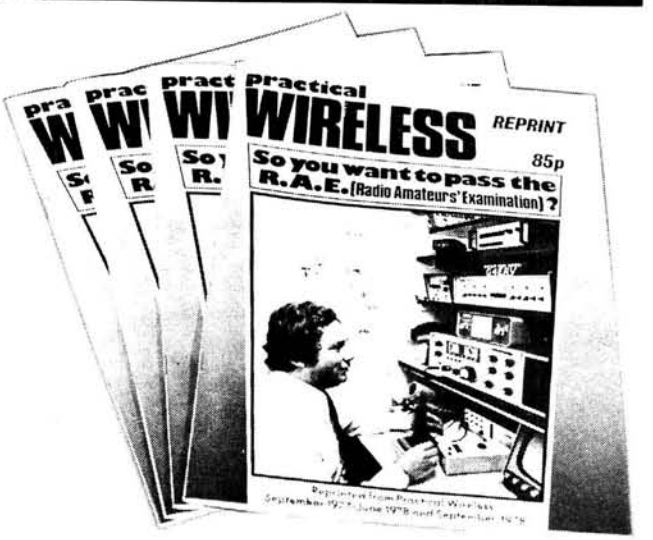

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